Comparison of mechanical properties, wear, corrosion and fatigue behavior of die- and sand-cast AlZn10Si8Mg alloy

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Abstract
The microstructural, mechanical, wear, corrosion and fatigue properties of AlZn10Si8Mg alloys cast using sand molds and permanent molds (die casting) are compared in detail. In addition, the obtained results were compared with those for traditional AlSi10Mg alloy.

Keywords: AlZn10Si8Mg aluminum alloy, self-hardening, microstructure, mechanical properties, wear.

Introduction
Self-hardening AlZn10Si8Mg alloys are known as a group of Al-alloys that exhibit twice the strength and 50% higher fatigue life compared to conventional Al-alloys without requiring additional heat treatment [1]. The absence of a heat-treatment requirement provides economic advantages in production, improves time efficiency, and offers environmental benefits. The proposed study has two innovative aspects: (i) the absence of any study in the literature comparing sand casting and metal mold casting of AlZn10Si8Mg alloys, and (ii) the highly comprehensive nature of the proposed work, which includes microstructural characterization, tensile, hardness, impact and wear tests.

Experimental procedure
AlZn10Si8Mg and AlSi10Mg alloys were produced via traditional sand- and die casting methods. The casting temperature was 700-710 °C. Any modification, refinement and heat-treatment were not applied to AlZn10Si8Mg alloys. However, traditional T6 heat-treatment was applied to AlSi10Mg alloys.

Table 1. Chemical analysis of AlZn10Si8Mg and AlSi10Mg alloys

	Si	Zn	Fe	Mg	Ti	Cu
AlZn10Si8Mg	8.45	10.15	0.201	0.241	0,100	0.048
AlSi10Mg	8.26	0.026	0.183	0.261	0.096	0.048

Tensile tests were conducted using an ALSA KTM 600 model universal testing machine at a deformation rate of 8 mm/min. Brinell hardness tests were conducted utilizing a Bulut Makine Digirock RBOV model hardness tester under a load of 62,5 kgf. Wear experiments were performed using a UTS Tribolog tribometer operating in a reciprocating ball-on-disc configuration.

Result and discussion
Table 2. Tensile properties of the AlZn10Si8Mg and AlSi10Mg alloys.

Condition	Tensile Strength (MPa)	Elongation (%)
AlSi10Mg sand-cast	187 ± 5	2.8 ± 0.2
AlSi10Mg die-cast	209 ± 10	2.9 ± 0.5
AlSi10Mg sand cast-T6	256 ± 4	1.4 ± 0.2
AlSi10Mg die cast-T6	286 ± 4	2.6 ± 0.2
AlZn10Si8Mg sand-cast	260 ± 2	1.3 ± 0.3
AlZn10Si8Mg die-cast	308 ± 2	2.0 ± 0.4

Table 3. The results of Brinell hardness and impact tests of the AlZn10Si8Mg and AlSi10Mg alloys

Condition	Brinell Hardness (HB)	Impact Energy (J)
AlSi10Mg sand-cast	58 ±	3.7 ± 0.5
AlSi10Mg die-cast	64 ±	3.9 ± 0.1
AlSi10Mg sand cast-T6	82 ±	2.6 ± 0.1
AlSi10Mg die cast-T6	82 ±	3.2 ± 0.2
AlZn10Si8Mg sand-cast	105 ±	1.9 ± 0.1
AlZn10Si8Mg die-cast	109 ±	2.1 ± 0.1

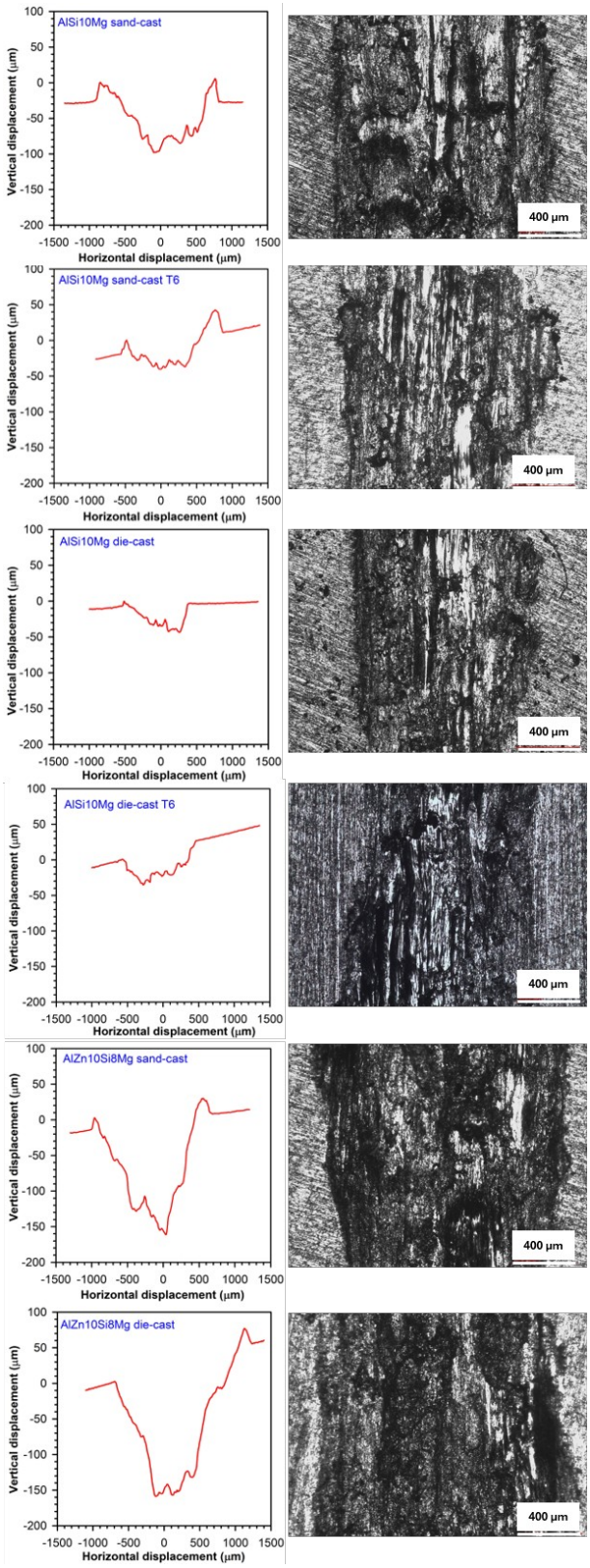

Figure 1. 2D wear profile scanned along the vertical direction of wear tracks and optical micrographs (100X) showing the worn surfaces.

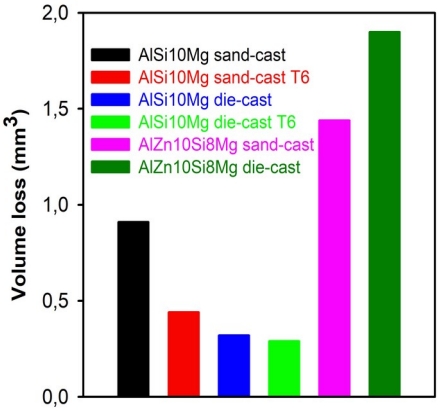

Figure 2. Calculated volumetric wear loss for studied alloys and conditions.

The measured mechanical properties of studied AlZn10Si8Mg and AlSi10Mg alloys are shown in Tables 2 and 3. Die-cast specimens exhibits higher strength, hardness and impact energy values compared to those for sand-cast specimens due to the relatively higher cooling rate. In addition, T6 heat-treatment improved mechanical properties of AlSi10Mg alloys as expected. Among investigated alloys and conditions AlZn10Si8Mg shows the highest strength and hardness values. The 2D profilometric images of the wear tracks along with optical micrographs of worn surfaces for all conditions are illustrated in Figure 2. In addition, the volumetric wear loss values are also given in Figure 3. AlSi10Mg exhibited significantly lower wear losses than AlZn10Si8Mg under all investigated conditions. T6 heat treatment reduced the wear volume of sand-cast and die-cast samples. In contrast, AlZn10Si8Mg exhibited considerably higher wear volumes. Although the die-cast AlZn10Si8Mg alloy showed the highest tensile strength, it also exhibited the greatest material loss during sliding. The poor tribological performance may be associated with nature, morphology, and distribution of Zn-containing/intermetallic phases, their susceptibility to fracture or pull-out.

Conclusion

AlZn10Si8Mg exhibits the best mechanical properties with highest strength and hardness without any heat-treatment. The die-cast AlSi10Mg-T6 condition provides the best tribological performance with lowest wear loss.

References

[1] Mikolajčík, M., Kuchariková, L., Tillová, E. et al. Influence of copper addition on the mechanical properties and corrosion resistance of self-hardening secondary aluminium alloy AlZn10Si8Mg. Metals, 2024, 14(7), 776.